Role of ultra-thin Ta-Si interlayer on thermal stability of Ta/Si films studied by *in-situ* x-ray scattering

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Tantalum/Si thin films have been extensively investigated as a diffusion barrier for copper metallization in integrated circuit devices due to its thermal stability and electrical properties. Although tremendous investigations of tantalum have been reported in order to improve thermal stability and resistance and to reveal failure mechanism related to silicide formation at high temperature regime, only few studies on real time behavior of Ta/Si system have been carried out. In this work, we have investigated different silicide formation process as well as its effect on thermal stability of Ta/Si (100) thin films using in-situ x-ray scattering and transmission electron microscopy (TEM).

Tantalum films were grown on Si(100) substrates by RF sputtering method in an *in-situ* chamber in which the structural properties of the films were measured during annealing process. The as-deposited Ta films are composed of α-Ta and β-Ta phases and also amorphous region. At around 500℃ annealing temperature, 1.5nm-thick interlayer is uniformly formed at the interface and continuously grows upto 20Å with increasing annealing temperature to 750℃. Whenever this interlayer is formed at the interface, the Ta film is quite thermally stable up to 750℃ without any structural deterioration. Meanwhile, Ta film without interlayer (directly annealed at 640℃) transformed to randomly nucleated tantalum silicide phase throughout whole film even at 660℃ resulting in degradation of Ta film. From x-ray reflectivity and TEM analysis, the interlayer is amorphous and quite close to TaSi2 phase. In addition, the formation of interlayer is sensitively dependent on initial annealing temperature. It should be stressed that Ta film with uniform nano-thin tantalum silicide interlayer could be a strong factor for thermal stable condition on Ta/Si(001).

References

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